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Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

00203396.7

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

I.L.C. HATTEN-HECKMAN

DEN HAAG, DEN
THE HAGUE, 19/04/01
LA HAYE, LE

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Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

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Koninklijke Philips Electronics N.V.
5621 BA Eindhoven
NETHERLANDS

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Titre de l'invention:
Method and X-ray apparatus for optimally imaging anatomical parts of the human anatomy

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Method and X-ray apparatus for optimally imaging anatomical parts of the human anatomy

The invention relates to a method for imaging the anatomical parts of the human anatomy by use of an X-ray apparatus as well as to an X-ray apparatus having an X-ray source and an X-ray detector facing the X-ray source, the X-ray source and the X-ray detector being movable with respect to each other and with respect to the patient so as to enable the acquisition of projection images of the anatomy from different positions and/or orientations.

A method for imaging the human spine by use of a CT system is known from US 5,946,370. Therein two-dimensional data from CT scout images are combined with three-dimensional information from CT scans using simple modelling of vertebrae. It is often, however, preferred to image the human spine of the patient in an upright position. Therefor a CT system cannot be used.

In digital X-ray imaging a composition of an image from sub-images is generally used to form a composite image of an elongate scene which is too long to be reproduced in one operation. In medical X-ray diagnostics such a situation occurs notably when an image of the spinal column is made. Using a contemporary digital X-ray examination apparatus it is difficult or even impossible to form an X-ray image of the complete region of the spinal column of the patient to be examined in one exposure. A number of successive X-ray images of portions of the region to be examined are formed, which images together cover the entire region. A method of this kind which is also called translation reconstruction technique is known from EP 0 655 861 A1. Such technique can also be used for imaging other anatomical parts of the human anatomy.

Due to the complexity of the scene - around the spinal column there are other portions of the body located like the thorax, rib cage, abdomen, head and neck, which are also imaged when imaging the spine - and due to the mixture of over-projecting structures, projection images are often of a low quality and limit the diagnostic reliability. Already when imaging a normal-curved spine there are portions of the spine where neighbouring vertebrae

may overlap each other in projection images. Further, when the spine of a patient shows an abnormal curvature, e.g. an exagerated forward curvature (lordosis), an exagerated backward curvature (kyphosis) or a lateral curvature (scoliosis) such overlapping structures occur even more in the curved portions of the spine reducing the quality of the projection images further. Another problem arises when the vertebrae of the spine show an axial rotation. Consecutive projection images taken all from the same direction will then show axially rotated vertebrae from different angles reducing the diagnostic value of these images.

The translation reconstruction technique gives easy access to digital overview images of a large part of the human anatomy like the spine. Additionally, fluoroscopy can be used to position the patient and the collimators of the X-ray apparatus optimally. However, much of the information in this fluoroscopy data is currently not used in order to plan and optimize the real acquisition of images of the anatomical parts.

It is therefore an object of the invention to provide a method and an X-ray apparatus for imaging the anatomical parts resulting in a better image quality and improving the diagnostic value and accuracy of the images.

This object is achieved according to the invention by a method as claimed in claim 1 and by an X-ray apparatus as claimed in claim 17.

It has been recognized according to the invention that information contained in at least one initial projection image can be used to reposition the X-ray apparatus automatically for subsequent imaging in an optimal way of the region of interest of anatomical parts. This means that the information contained in the initial projection image is used to determine the optimum imaging parameters like position, direction, collimation or exposure parameters for the anatomical parts from their position and/or orientation in the initial image. This determination of the optimum imaging parameters can be done for each single anatomical part or groups of anatomical parts. Thereafter images of single parts or groups of parts can be acquired using the optimum imaging parameters, and the images can be displayed separately, i.e. subsequently or side-by-side at the same time, or can be combined according to the translation reconstruction technique forming a (curved) composite image, e. g. of the complete spinal column (if the acquisition trajectory allows this). To find

the optimum imaging parameters the positions and/or orientations of parts or groups of parts are determined in the initial projection images using known methods.

Additionally or alternatively to the information contained in the at least one initial projection image other sources of information can be used to determine the positions and/or orientations of the anatomical parts of interest. Such sources of information can be general knowledge about the anatomy, in particular knowledge about the positions and/or orientations of an average anatomy or about special features of an abnormal anatomy, knowledge from previous examinations and/or images of the same patient. Further other knowledge about the patient, like his weight and/or height, can also be used as other source of information.

In a preferred embodiment the optimum exposure and/or collimator settings are determined from the positions, orientations and/or the appearance of the anatomical parts in the at least one initial projection image. In this embodiment at first a complete scan or a fluoroscopy series which can selectively be reconstructed into an overview image can be acquired, where each image retains all acquisition settings. After having indicated the parts of interest, e.g. the apex vertebrae of a scoliotic curve of the spine, the X-ray apparatus can then automatically acquire snapshots of all parts of interest. It can be translated automatically to align each parts with the line-of-sight or it can be zoomed in for optical magnification by reducing the source-object distance or by increasing the detector-object distance. Further, the collimator can be adjusted to only irradiate the parts of interest. It can be radiated with the optimal exposure settings as learnt from the initial acquisition exposure settings and the resulting contrast, noise and/or blackness of the initial image. This will result in optimally positioned, zoomed and contrasted snapshots of individual parts of interest.

Alternatively, a frontal view image of the anatomy, preferably with extremely low X-ray dose, is acquired first. Therein the region of interest is drawn, e.g. the envelope of the spinal column. Thereafter, the region of interest is scanned optimally, which means that the start and stop positions, the collimation and the exposure control are optimized for the content of the region of interest. This may be a compromise for a certain target region, or allow really local adaptations, and maybe while varying these parameters smoothly from one image to the next. This greatly improves the image quality of the region of interest while reducing the overall X-ray dose to the patient.

Preferably, the optimum projection lines for acquiring projection images of the anatomical parts are determined from the positions and/or orientations of the anatomical parts. In particular, if the anatomy, e. g. the spinal column, is deformed it is beneficial to adapt the projection lines to this deformation. Depending on the strength of deformation the lateral and/or frontal tilt angle of the anatomical parts may be different for each anatomical part and/or an axial rotation of the anatomical parts, e. g. the vertebrae may occur. This requires to adapt the projection line to the specific position and/or orientation of an anatomical part. Preferably, this is done for each anatomical part.

Preferably the at least one initial projection image is taken as a lateral or a frontal image. The selection of the direction of the initial projection image depends on the direction of the projection images to be taken and on the specific curvature of the anatomy to be examined. A specific frontal and/or lateral image is then used in another preferred embodiment to determine the frontal and/or lateral spine axis and/or the frontal and/or lateral tilt angles of the vertebrae.

In still another preferred embodiment the at least one initial projection image is an overview image reconstructed from at least two projection images. Preferably, this overview image is determined from a series of fluoroscopy images with known 3D position. The overview image which can be a lateral or a frontal overview image will then be used to determine the positions and/or orientations of anatomical parts in the region of interest.

The method according to the invention is preferably used for imaging the human spine, comprising the steps as claimed in claim 8. The information contained in the at least one initial projection image is therein used to reposition the X-ray apparatus automatically for subsequent imaging of the region of interest of the spine or specific parts thereof. Optimum imaging parameters are thus determined for the vertebrae from their position and/or orientation in the initial image. This determination of the optimum imaging parameters can be done for each single vertebra or groups of vertebrae. Thereafter images of single vertebrae or groups of vertebrae can be aquired using the optimum imaging parameters, and a (curved) composite image of the complete spinal column can be aquired. To find the optimum imaging parameters the positions and/or orientations of vertebrae or groups of vertebrae are determined in the initial protection image(s) using known methods.

In a preferred embodiment, the spinal axis line is determined from the at least one projection image and the projection lines are set perpendicular to the spinal axis line. Alternatively, the tilt angles of the vertebrae are determined from the initial projection image, and the projection lines are set parallel to the endplates of the vertebrae. Preferably one projection line per vertebra is determined in these preferred embodiments. Depending on the acquisition of projection images from the lateral or frontal direction the frontal or lateral spinal axis line and/or tilt angle of the vertebrae are determined from the initial projection image. This information is used to angulate dynamically to align with the projection lines for each vertebral body during the frontal or lateral scan. This results in a series of lateral and/or frontal projection images that are all as much parallel as possible to the endplates of the vertebrae, and thus in a better vertebral body image quality. For the lateral images this alleviates the well-known problem of low quality lateral images for patients with large frontal curves, due to disturbing overprojections and due to the fact that the projections are far from parallel to the vertebral endplates.

In an advantageous embodiment the axial rotation of the vertebrae is determined from the initial projection image, and the projection lines are set by use of the axial rotation of the vertebrae. By use of this information the source-detector unit is rotated while acquiring projection images of the vertebrae to compensate for axial rotation. This results in views of vertebrae with no or only a small axial rotation, i.e. real frontal views with respect to a local vertebrae coordinate system. Acquisitions perpendicular to these minimum axial rotation views will result in real lateral views. A combination of the initial axial rotation estimate and the remaining small rotation will result in more accurate axial rotation measurements.

In another preferred embodiment an optimum scanning trajectory for subsequently acquiring projection images of the vertebrae is determined. When subsequently acquiring the projection images the X-ray source and detector are then dynamically angulated and/or rotated to align with the optimum projection line for each vertebra resulting in optimum projection images.

According to still another preferred embodiment a 3D spinal axis model is fitted to a pair of overview images, and an optimum scanning trajectory is determined from

the fitted 3D spinal axis model. Therefor, preferably a frontal and a lateral overview image are acquired first to which the 3D spinal axis model is fitted. The optimum scanning trajectory is a smooth trajectory that looks for a compromise of projection parameters for a series of consecutive vertebrae.

In order to determine the positions and/or orientations of the vertebrae in the initial projection image anatomical landmarks of the vertebrae, in particular the corners and pedicles of the vertebrae, are used. These pedicles can preferably be used to determine the axial rotation of a vertebral body since there shows an assymmetry of the pedicle shadows in a plane perpendicular to a vertebral axis when the vertebral body is axially rotated.

Other preferred embodiments of the method for imaging the anatomical parts, in particular the human spine, according to the invention are set forth in further subclaims.

The invention can in general be used for imaging different anatomical parts of the human anatomy. In particular, the invention is applicable for imaging the hip, the lower limbs, e. g. intrinsic rotation of the femur with respect to the throchanter or femur head, the knees and ankle and the rib cage. Preferably the invention is used for imaging the human spine or parts thereof.

An X-ray apparatus according to the invention for imaging the anatomical parts of the human anatomy is claimed in claim 17, comprising a control unit and a processing unit. It shall be understood that this X-ray apparatus can be developed further and that there are further preferred embodiments thereof which further embodiments are developed further in the same or similar way as described above and as laid down in the subclaims of the method according to the invention.

These and other aspects of the invention will become apparent from and will be explained in more detail with reference to the following embodiments and the accompanying drawings, in which

Fig. 1 shows a side elevation of an X-ray examination apparatus for forming X-ray images in accordance with the invention;

Figs. 2A and 2B show the spinal column in a frontal and a lateral view;

Fig. 3 illustrates the acquisition of frontal projection images in accordance with the invention;

Fig. 4 illustrates the acquisition of projection images of an axially rotated spinal column in accordance with the invention; and

Fig. 5 illustrates the acquisition of lateral projection images in accordance with the invention.

Fig. 1 is a side elevation of an X-ray examination apparatus for forming X-ray images of a patient 12 to be examined as it is known in general from EP 0 655 861 A1. An X-ray source 1 and an X-ray detector 2 are connected to a carrier 3, for example a C-arm. The C-arm 3 is movably connected to a vertical support 5 by means of a sleeve 4. The vertical support is rotatable around a substantially vertical axis of rotation 6 and is suspended from a set of rails 7 mounted on the ceiling of the room in which the X-ray examination apparatus is installed. A patient table 8 is movably connected to a frame 9 which is mounted on a column 10. The frame 9 can be moved up and down of the column 10 so as to adjust the height of the table relative to the X-ray source 1. The patient table is movable relative to the frame 9 in order to enable displacement in the longitudinal direction of the patient table 8 on which the patient 12 is arranged. The C-arm 3 with the X-ray source 1 and the X-ray detector 2 can further be angulated around a horizontal propeller axis 14 and rotated around a second horizontal patient axis 15 both being perpendicular to each other and to the vertical rotation axis 6.

In this configuration the patient 12 is positioned on the patient table 8 during the examination, and the C-arm 3 with the X-ray source 1 and the X-ray detector 2 and the patient table 8 with the patient 12 are displaced relative to one another, separate X-ray images being formed in separate mutual positions. It is alternatively possible for the patient 12 to stand upright during the examination, the C-arm 3 then being moved vertically along the patient 12. This is the normal system and the normal position of the patient used for imaging the spine.

An optical image which is derived by the X-ray image intensifier 2 from an X-ray image at its entrance screen is picked up by a camera 13, and the image signal is transferred to an image processing unit 16 for further processing. Therein several sub-images subsequently taken of different portions of the spine of the patient 12 can be combined so as to form a composite image. Further, image data of several X-ray images derived at different positions and from different angles of the X-ray source 1 and X-ray detector 2 with respect to the patient 12 can be combined so as to form a three-dimensional data set which can be used to calculate a desired image, e.g. of a certain slice of the patient or a projection image from a certain direction. The sub-images, the composite image or other calculated images can be displayed on a display, either subsequently or side-by-side.

The X-ray apparatus, in particular the movement of the C-arm 3 and of the patient table 8, is controlled by a control unit 17. For imaging of the human spine sub-images (projection images) are taken subsequently of neighbouring portions of the spine, the patient 12 either being in a horizontal position lying on the patient table 8 or being in an upright position. Due to several overlapping structures in the body around the spine as well as due to the overlapping of neighbouring vertebrae of the spine and further due to the curvature of the spine which can be in the forward, backward and/or lateral direction, the X-ray examination apparatus is controlled during the acquisition of the sub-images such that the projection line 18, i.e. the line from the center of the source 1 to the center of the detector 2, is adapted to the position of the vertebra or several vertebrae being actually imaged. This means that the C-arm 3 will be angulated around the propeller axis 14 and/or rotated around the patient axis 15 during the acquisition of the sub-images depending on a scanning trajectory calculated in advance from at least one initial projection image, e.g. a rough overview image. This will be explained in more detail with reference to Figs. 2 to 5.

Fig. 2A shows a normal frontal view of a human spinal column, and Fig. 2B shows a normal lateral view thereof. As indicated by letters "A" and "B" in these figures, there are regions with overlapping structures, i.e. portions of neighbouring vertebrae may overlap in projection images taken in any horizontal direction perpendicular to the patient axis 15. The diagnostic value of such images is thus reduced. The reason for this overlap is that in the regions A and B the endplates E1, E2 of the vertebrae V are not parallel to a horizontal plane oriented perpendicular to the patient axis 15. This problem can also occur in

other regions of the spinal column, e.g. in the region C where the spinal column shows a normal kyphosis or in the region D where the spinal column shows a normal lordosis. This problem is still increased if the spinal column of a patient is even more curved showing an abnormal kyphosis or an abnormal lordosis. The spinal axis line 19 will then be even more curved as shown in Fig. 2B.

Additionally, the spinal column can be curved in the frontal view in the lateral direction, and/or one or more vertebrae can be tilted in the lateral direction such that the endplates E1, E2 of a vertebra are not parallel to a lateral horizontal projection line perpendicular to the patient axis 15 and to the drawing plane of Fig. 2B. Such tilted vertebrae in the lateral direction particularly occur when a patient suffers from scoliosis where the spinal axis line is curved in the lateral direction.

Fig. 3 shows a first embodiment of the invention. Therein frontal views of the spinal column 20 of the patient 12 shall be acquired. Preferably these frontal views are acquired when the patient 12 is in an upright position. According to the invention at first a lateral overview image, preferably with a low X-ray dose, is acquired as the at least , preferably including the vertebral column 20 completely. The overview image is determined from several initial projection images of different portions of the spinal column 20. Therein the region of interest, e.g. the complete spinal column 20 or portions thereof, can be drawn. Then the spinal axis line 21 is detected by known measures, and the lateral tilt angles α of the vertebrae of interest are measured by known methods. This information about the spinal axis line 21 and/or the tilt angles is used to generate a set of projection lines 181, 182, 183, 184 perpendicular to the axis line 21. As indicated in Fig. 3, the tilt angle $\alpha 1$ for the projection line 183 is different compared to the tilt angle $\alpha 2$ of the projection line 184. In general, the tilt angle is defined here as the average angle of both endplates of a vertebra with respect to the patient axis 15. The angle between the projection line and the patient axis 15 is then made equal to this tilt angle for each vertebra.

Preferably, one projection line is determined for each vertebra in the region of interest. From all these projection lines - in Fig. 3 there are only four projection lines 181 to 184 shown, it will be more projection lines in practice - a scanning trajectory is generated along which the X-ray source 1 and the X-ray detector 2 are dynamically moved when subsequently acquiring projection images of the spinal column 20. Thus, the X-ray source 1

and the X-ray detector 2 are dynamically angulated to align with a projection line for each vertebral body. This results in a series of frontal projections that are all as much parallel as possible to the endplates of the vertebral body. This alleviates the well-known problem of low quality frontal images for patients with large frontal or backward curves due to disturbing overprojections and due to the fact that the projections are far from parallel to the vertebral endplates.

The projection images acquired can be combined forming a composite image which combination requires an additional processing effort, or the projection images can be displayed separately. The angulation of each image is mentioned with the image as a rough indication of the lateral tilt angle and to allow the interpretation of the image.

With reference to Fig. 4 another embodiment of the invention will be explained. The spinal axis line 19 shown in Fig. 4 is curved in the lateral direction. Additionally the vertebrae V1-V6 are rotated around the spinal axis line 19 as indicated by the arrow R. The spinal column of a patient suffering from scoliosis typically shows such a curvature and such a rotation of the vertebrae.

According to the invention one or more initial frontal projection images are acquired first. Therefrom the axial rotation of the vertebrae is estimated or measured, in particular by comparing the pedicle positions with respect to the vertebral body center. By use of this information for each vertebra or for each group of vertebrae projection images are acquired while rotating the source-detector unit to compensate for the axial rotation of the vertebrae. This results in views of the vertebrae with no or only a small axial rotation, e.g. in real frontal views with respect to a local vertebrae coordinate system. Acquisitions perpendicular to these minimal axial rotation views will result in real lateral views. A combination of the initial axial rotation estimate and the remaining small rotation will result in more accurate axial rotation measurements. As can be seen in Fig. 4, the projection lines 185, 186, 187 are rotated around the spinal axis line 19 depending on the rotation of the vertebra which is to be imaged along this projection line.

A third embodiment will be explained in more detail with reference to Fig. 5. Therein, a frontal view of the spinal column 20 is shown having a double major curve. Such a curvature appears with patients suffering from scoliosis. To acquire high quality lateral

projection images at first a frontal overview image is acquired. Preferably, the spinal axis line is shown therein completely or at least the region of interest of the spinal axis line. From the overview image the spinal axis line is detected or indicated and/or the frontal tilt angles β of some or all vertebrae of interest are measured. By use of this information a set of projection lines 188, 189, 190, 191 perpendicular to the spinal axis line or by making use of the tilt angles β is generated. Preferably, one projection line per vertebra is generated. The tilt angles β are therein defined as the angles between a projection line, which is parallel to the endplates of the vertebra to be imaged, and the patient axis 15 as shown in Fig. 5. As can be clearly seen in this figure, the tilt angles β1 and β2 are quite different due to the lateral curvature of the spine.

From the projection lines 188 - 191 a scanning trajectory 23 is generated along which the X-ray source 1 and the X-ray detector 2 are moved while acquiring projection images of the spinal column 20. Therefore, the source-detector unit is rotated to the lateral view, translated from start to stop position, and angulated dynamically to align with the projection lines for each vertebral body or for each group of vertebral bodies. This results in a series of lateral projections that are all as much parallel as possible to the endplates of the vertebrae. This alleviates the well-known problem of low quality lateral images for patients with large lateral curves, due to disturbing overprojections and due to the fact that the projections are far from parallel to the vertebral endplates.

In the above preferred embodiments of the invention are explained. However, the claims are not limited to these embodiments. Modifications and further embodiments of the invention are also possible. In particular, frontal and lateral overview images can be acquired to fit a three-dimensional spinal axis model to these images and to calculate an optimal three-dimensional scanning trajectory therefrom along which a series of images is acquired.

According to the invention the X-ray source and detector positions are controlled by image information in order to obtain optimal view of specific parts of the spinal column automatically. The image information can be used to set the collimation, the exposure parameters and the projection orientation optimally and automatically. An X-ray apparatus preferably used to execute this method, should allow movements along two axes, i.e. for horizontal and vertical translation, and around at least two axes, i.e. should allow a

rotation and angulation like a C-arm or a U-arm. Further, the exposure, the collimation and the projection geometry should be fully controllable, and a registration of all image acquisition information like geometry, table position, exposure and collimation settings should be possible. Preferably, it should be possible to determine acquisition settings using information that the operator or an automatic algorithm can obtain from intermediate or overview images.

CLAIMS:

1. Method for imaging anatomical parts of the human anatomy by use of an X-ray apparatus, the method comprising the steps of

- acquiring at least one initial projection image of at least the region of interest of the anatomy,
- determining the positions and/or orientations of the anatomical parts in the region of interest from the at least one initial projection image and/or from other sources of information,
- determining the optimum imaging parameters for the anatomical parts from their positions and/or orientations, and
- acquiring images of the anatomical parts using the optimum imaging parameters.

2. Method according to claim 1,
characterized in that the optimum exposure and/or collimator settings are determined from the positions, orientations and/or appearance of the anatomical parts in the at least one initial projection image.

3. Method according to claim 1,
characterized in that the optimum projection lines for acquiring projection images of the anatomical parts are determined from the positions and/or orientations of the anatomical parts.

4. Method according to claim 1,
characterized in that the at least one initial projection image is taken as a frontal and/or a lateral image.

5. Method according to claim 1,
characterized in that the at least one initial projection image is an overview image reconstructed from at least two projection images.

6. Method according to claim 1,
characterized in that for each anatomical part in the region of interest an optimum projection line is determined.

7. Method according to claim 1,
characterized in that the acquired images of the anatomical parts are displayed separately or combined to a composite image for display.

8. Method according to claim 1,
characterized in that the method is used for imaging the human spine, comprising the steps of:

- acquiring at least one initial projection image of at least the region of interest of the spine,
- determining the positions and/or orientations of vertebrae in the region of interest from the at least one initial projection image,
- determining the optimum imaging parameters for the vertebrae from their positions and/or orientations, and
- acquiring images of the vertebrae using the optimum imaging parameters.

9. Method according to claim 8,
characterized in that the spinal axis line is determined from the at least one projection image and that optimum projection lines are set perpendicular to the spinal axis line.

10. Method according to claim 8,
characterized in that the tilt angles of the vertebrae are determined from the at least one initial projection image and that the projection lines are set parallel to the endplates of the vertebrae.

11. Method according to claim 8,
characterized in that the axial rotation of the vertebrae is determined from the at least one initial projection image and that the projection lines are set by use of the axial rotation of the vertebrae.

12. Method according to claim 8,

characterized in that the frontal and/or lateral spine axis and/or the frontal and/or the lateral tilt angles of the vertebrae are determined from a frontal or lateral initial projection image.

13. Method according to claim 9, characterized in that an optimum scanning trajectory for subsequently acquiring projection images of the vertebrae is determined by angulating and/or rotating the X-ray source and detector dynamically to align with the optimum projection line for each vertebra.

14. Method according to claim 8, characterized in that a 3D spinal axis model is fitted to a pair of overview images and that an optimum scanning trajectory is determined from the fitted spinal axis model.

15. Method according to claim 8, characterized in that landmarks of the vertebrae, in particular the corners and pedicles of the vertebrae, are used to determine the positions and/or orientations of the vertebrae.

16. Method according to claim 1, characterized in that as other sources of information for determining the positions and/or orientations of the anatomical parts general knowledge of the anatomy, knowledge from previous examinations and/or images of the same patient and/or other knowledge about the patient, like weight and/or height, is used.

17. X-ray apparatus for imaging the anatomical parts of the human spine having an x-ray source and an x-ray detector facing the x-ray source, the x-ray source and the x-ray detector being movable with respect to each other and with respect to the patient so as to enable the acquisition of projection images of the anatomical parts from different positions and/or orientations, the x-ray apparatus comprising

- a control unit for controlling the x-ray apparatus such that at least one initial projection image of at least the region of interest of the anatomy is acquired, and
- a processing unit for determining the position and/or orientation of anatomical parts in the region of interest from the at least one initial projection image and/or from other sources of information and for determining the optimum imaging parameters for the anatomical parts from their positions and/or orientations, the optimum imaging parameters

being used by the control unit to control the x-ray apparatus such that images of the anatomical parts using the optimum imaging parameters are acquired.

ABSTRACT:

The invention relates to a method and an X-ray apparatus for imaging anatomical parts of the human anatomy, in particular for imaging the human spine. To improve the quality and the diagnostic value of projection images of the anatomical parts (20) it is proposed according to the invention to acquire at least one initial projection image of at least the region of interest of the anatomy (20), to determine the positions and/or orientations of the anatomical parts in the region of interest from the at least one initial projection image and/or from other sources of information, to determine the optimum imaging parameters for the anatomical parts from their positions and/or orientations, and to acquire images of the anatomical parts using the optimum imaging parameters. The complexity of the scene and the mixture of over-projecting structures limiting the diagnostic reliability of the projection images is thus being taken into account. In a preferred embodiment a scanning trajectory (21) is determined using the information of the at least one initial projection image along which the source-detector unit (1, 2) is moved while acquiring the projection images of the spine (20).

(Fig. 3)

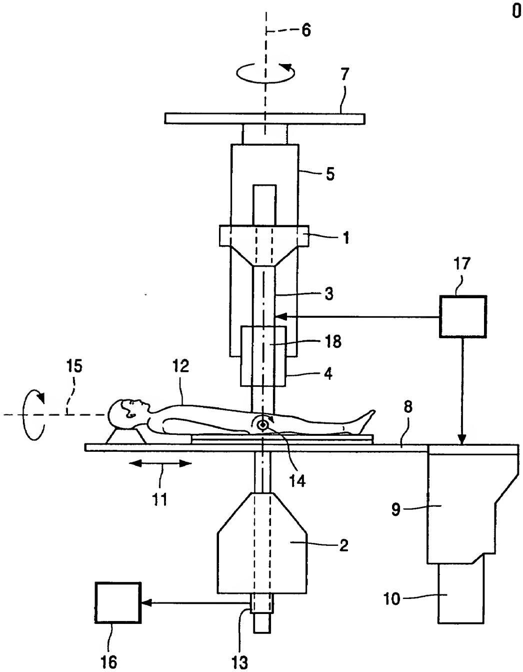

FIG. 1

2/4

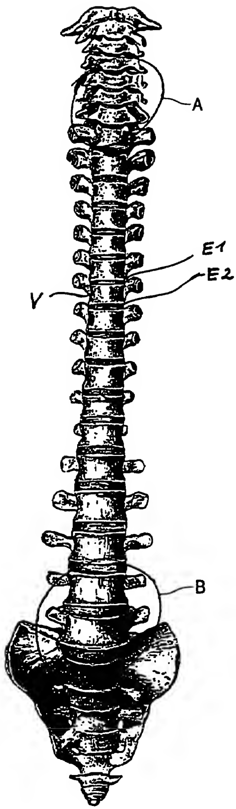

FIG. 2A

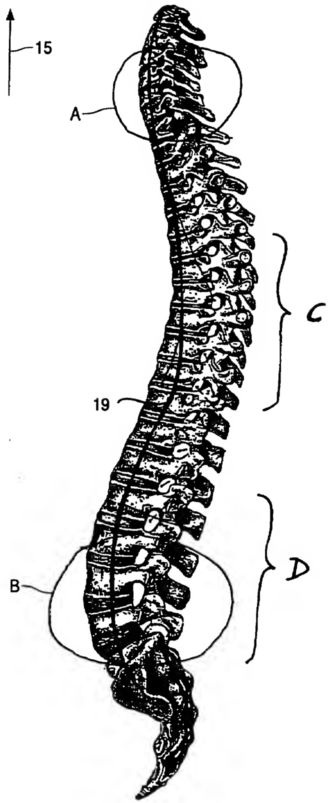

FIG. 2B

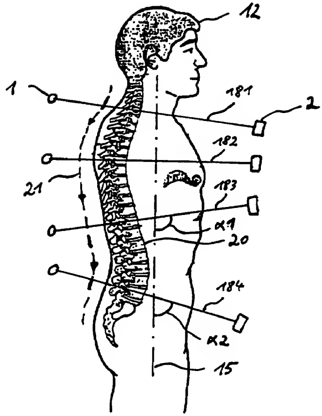
12
1
181
2
182
21
183
α1
20
184
α2
15

FIG. 3

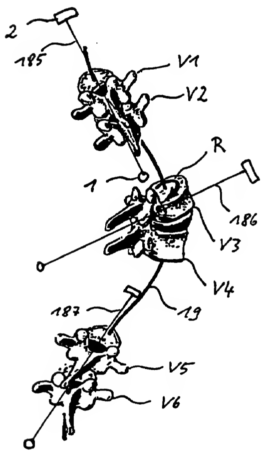
2
185
V1
V2
R
1
186
V3
V4
187
19
V5
V6

FIG. 4

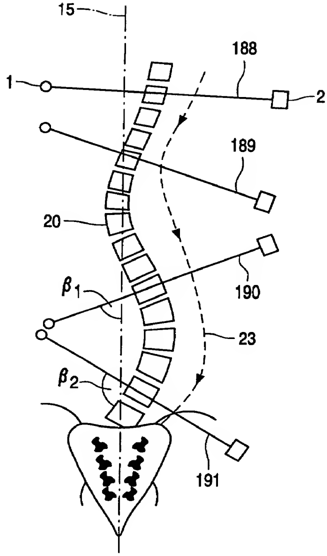

FIG. 5